Neptune.

Sept.	1,	6	15	+ 22	18	12	15	A.M.	7	36	A.M.	2	57 P.M.
Oct.	1,	6	16	+ 22	17	10	19	P.M.	5	40		1	1
Nov.	1,	6	15	+ 22	16	8	16		3	37		10	58 A.M.

Eclipses of *Jupiter's* Satellites, P. S. T.

(Off right-hand limb as seen in an inverting telescope.)

I, R,	Sept.	1,	2^h	40^m	A.M.	III, D,	Oct.	1,	5^h	25^m P.M.
I, R,		2,	9	9	P.M.	III, R,		1,	8	58
II, R,		5,	10	35		I, R,		2,	11	18
I, R,		9,	11	4		I, R,		4,	5	47
I, R,		11,	5	32		II, R,		7,	10	22
II, R,		13,	1	12	A.M.	III, D,		8,	9	26
IV, R,		15,	4	53	P.M.	III, R,		9,	12	59 A.M.
I, R,		17,	12	59	A.M.	I, R,		11,	7	42 P.M.
I, R,		18,	7	26	P.M.	I, R,		18,	9	38
II, R,		23,	5	7		I, R,		20,	4	7
III, R,		24,	4	57		II, R,		25,	4	56
I, R,		25,	9	23		I, R,		25,	11	33
I, R,		27,	3	52		I, R,		27,	6	2
II, D,		30,	7	44						

DEFINITIVE DETERMINATION OF THE ORBIT OF COMET 1898 I.

[Abstract of No. 3 of the *Astronomische Abhandlungen.*]

By Heber D. Curtis.

Comet 1898 I was discovered by Professor C. D. Perrine at Mt. Hamilton on March 19, 1898. At this date it was about equal to a sixth-magnitude star, with a head nearly 2′ in diameter and a broad fan-shaped tail about a degree in length. In all, the comet was observed 666 times at thirty-four observatories. Deducting for incomplete observations, 640 were made in Right Ascension and 639 in Declination. The comet had just passed perihelion (March 17th) and was visible for nine months, during which time it swept over a heliocentric arc of 110°.

The comet presented no unusual phenomena in physical appearance or spectrum, with the exception of a sharp fan-

shaped jet in the head, which was observed by PERRINE on April 7th, and was still visible one month later. There was a very well-marked nucleus, which in good seeing was of star-like sharpness. Traces of this nucleus were still seen at Mt. Hamilton in the middle of September.

Telescopic comets of long apparition period and considerable range in distance from the Sun and from the Earth afford an excellent test for the applicability of the various laws which have been suggested in explanation of the decrease in the light of comets as they recede from the Sun. Estimates on such objects can be made in magnitudes much as stars are compared, and with much the same accuracy. As Comet 1898 I had a range of over ten magnitudes (6.5 to 16.7) during the nine months of its apparition period, in which time its radius-vector varied in length from 1.1 to 3.5 units, it may be of interest to compare its loss of light with the various formulæ which have been suggested. Eighty-eight estimates of the brightness of the comet as a whole were made at various observatories and sixty-seven of the starlike nucleus. The loss of light in the nebulosity as a whole and in the nucleus seems to have been synchronous, and to have obeyed the same law within the limits of observation, but neither comet nor nucleus follows the formulæ $J = \frac{C}{r^2}$ (DEICHMULLER, *A. N.*, 3123), $J = \frac{C}{\Delta^2}$ (OLBERS, *B. J.* 1819), nor the commonly accepted one, $J = \frac{C}{r^2\Delta^2}$, the difference on November 15th for the last expression being nearly seven magnitudes. The attempt was made to ascertain whether the variation in brightness could be expressed in the form $J = \frac{C}{\phi(r)\Delta^2}$. The various formulæ were applied to this comet and to several other comets of long apparition period, but no simple function of the inverse of r and Δ was found which would harmonize all the data. In the last column of the following abridged table will be found the residuals, in magnitudes, in the sense observation minus computation, secured on the assumption that the light varied in accordance with the formula $J = \frac{C}{r^7\Delta^2}$. This formula is of course purely empirical and rests upon no physical basis; it is of interest

simply in showing the inadequacy of the ordinary formula $J = \frac{C}{r^2 \Delta^2}$ for this comet.

a. Comet.

Place of Observation.	Date 1898.	Observed Mag.	O-C $C/r^2 \Delta^2$	O-C $C/r^7 \Delta^2$
Mt. Hamilton..	March 20 0	6.0	—0.5	—0.5
Utrecht.....	April 1.6	7.	+0 4	+0.4
Vienna.....	May 1.5	7.4	+0.2	—0.5
Munich.....	May 2.4	8.5	+1.3	+0 5
Munich.....	June 4.4	10.3	+2.1	0.0
Mt. Hamilton..	June 19.9	10.	+1.4	—1 2
Munich.....	July 16.5	12.0	+2.9	—0.6
Mt. Hamilton..	July 23.0	12.8	+3.6	—0.2
" "	Aug. 12.9	13.5	+4.0	—0.3
" "	Sept. 10.0	16.	+6.2	+1.3
" "	Nov. 6.8	16.8	+6.8	+0.4
" "	Nov. 15.8	16.8	+6.7	+0.5

b. Nucleus.

Place of Observation.	Date 1898.	Observed Mag.	O-C $C/r^2 \Delta^2$	O-C $C/r^7 \Delta^2$
Bamberg.....	March 22.6	8.9	+0.9	+0.9
Mt. Hamilton..	March 30.0	8.0	0.0	—0.2
Utrecht.....	April 13.5	9.0	+0.7	+0.4
Utrecht.....	May 11.5	9.5	+0.4	+0.2
Mt. Hamilton..	June 6.0	11.5	+1.7	—0.6
" "	June 28.9	13.3	+2.9	0.0
" "	July 10.0	14.	+3.5	+0.3
" "	July 30.0	16.	+5.2	+1.3
" "	Aug. 14.9	16.5	+5.4	+1.1
" "	Sept. 18.0	17.?	+5.7	+0.6
" "	Oct. 14.9	16.5	+5.1	+0.3

The observations depend upon 354 comparison-stars, whose places were determined after a comparison of all available catalogue places. The parallax factors were recomputed with a value of 8".80 for the Sun's parallax and the reductions to apparent place carefully checked.

The probable errors and weights to be assigned to each observer were found in part graphically, and from the weighted residuals nine normal places were formed. The comet did not pass near any of the planets, but the perturbations in rectangular coördinates were computed at intervals of sixteen days

during the apparition period for all the planets except *Uranus* and *Neptune.*

The dates of the normal places, the residuals and the perturbations are given in the annexed table:—

EPOCH OF OSCULATION: MARCH 31.0.

No.	1898	$\Delta\alpha \cos\delta$	Pert. α	Weight	$\Delta\delta$	Pert. δ	Weight	OBSERVATIONS. From	OBSERVATIONS. To
		"	"		"	"			
I	March 25.5	— 1.65	+ 0.002	132.5	— 1.20	— 0.001	153.0	March 19	March 31
II	April 14.0	— 0.72	+ 0.005	291.0	— 2.18	— 0.011	331.5	April 1	April 30
III	May 15.0	+ 1.22	+ 0.053	170.0	— 1.57	— 0.141	220.0	May 1	May 31
IV	June 16.0	+ 2.34	+ 0.387	51.0	— 1.90	— 0.259	83.0	June 1	June 30
V	July 18.5	+ 0.98	— 0.954	27.0	— 0.79	— 0.243	54.0	July 1	July 31
VI	Aug. 20.5	— 4.18	— 1.786	8.0	+ 1.58	— 0.147	16.0	Aug. 12	Aug. 28
VII	Sept. 16.5	— 7.26	— 2.725	10.0	— 0.14	— 0.100	20.0	Sept. 10	Sept. 19
VIII	Oct. 15.5	— 9.78	— 4.042	4.0	+ 2.35	— 0.332	8.0	Oct. 8	Oct. 19
IX	Nov. 11.5	— 6.30	— 5.330	7.0	+ 0.81	— 0.452	14.0	Nov. 6	Nov. 15

From these by the usual methods and with the application of the usual checks the following corrections to the elements were derived:—

$$d\,T = +\ 0^d.011825 \pm 0^d.001679$$
$$d\ \log q = +\ 0\ .0000524 \pm 0\ .0000093$$
$$d\,\pi' = +\ 1'\ \ 8''.52 \pm 11''.03$$
$$d\,\Omega' = +\ 0\ \ 18\ .07 \pm\ 3\ .21$$
$$d\,i' = -\ 0\ \ 1\ .80 \pm\ 0\ .49$$
$$d\,e = +\ 0\ .0004639 \pm 0\ .0000706$$
$$[vv] = 30''.64 \qquad [p\,vv] = 449''.1 \qquad [n\,n\,6] = 450''.5$$

The sum of the squares of the weighted residuals has thus been reduced from 4213″ to 450″.

From these are derived the following definitive elements:—

EQUINOX OF 1898.0.

$$T = 1898\ \text{March}\ 17.13078\ \text{Gr. M. T.}$$
$$\omega = 47^\circ\ 19'\ 11''.85$$
$$\Omega = 262\ \ 26\ \ 19\ .06$$
$$i = 72\ \ 31\ \ 47\ .01$$
$$\log q = 0.0395112$$
$$e = 0.9803852$$
$$\text{Period} = 417.2 \pm 2.2\ \text{years}$$

In inclination and longitude of the node it somewhat resembles Comet Pons-Brooks, 1884, but here the resemblance ceases. Comets 1861 I and 1861 II, both well determined, have approximately the same period, but no other likeness except a high inclination, that of 1861 I being 85° 26′, and 1861 II, 79° 46′.